INFANT FOOD

AND

INFANT FEEDING.

By PROF. EDGAR EVERHART, A. M., Ph. D.,

Professor of Chemistry, University of Texas.

READ BEFORE

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INFANT FOOD AND INFANT FEEDING.—By EDGAR EVERHART, A. M., Ph. D., Professor of Chemistry, University of Texas.

From various causes, it happens that a large percentage of infants are deprived of their natural nourishment, and it becomes necessary to resort to some substitute to sustain life. This deprivation of their natural food is sometimes complete, but more often it is only partial. It is difficult to say whether this percentage of infants deprived of mothers' milk is on the increase or not. Judging from the number of so-called Infant Foods on the market, the number of children who derive at least a part of their sustenance from this artificial source must be much greater than is commonly supposed. In many cases, no doubt, it is absolutely impossible for the child to obtain nourishment from the mother. Under such circumstances, of course resort must be had to some other food. Whenever the food is other than that provided by nature, too much care cannot be exercised in selecting that which most resembles, in its chemical and physiological properties, that most suitable of all infant foods—mothers' milk.

The importance of the question of substitutes for mothers' milk can hardly be overestimated. The mortality among infants is enormous. Until the present time, but few statistics have been taken with regard to the diet of infants who have died during the first year of their existence. It has been stated that, of 800,000 deaths that annually occur in the United States, 500,000 of them are infants. This statement, however, is not based upon anything more substantial than a reasonable supposition. It is practically impossible, with the present state of the enforcement of the laws, to give, with accuracy, such statistics. In Germany, where the taking of various statistics with regard to deaths, births, marriages, etc., is strongly insisted upon by the government, the following table has been recently issued with regard to the nourishment of infants: Of every

1000 children nourished by mothers' milk, 610 exhibited good health, 190 moderate health, 118 bad health, and 82 died by the end of the first year. Of 1000 infants nourished by the milk of a wet nurse, 260 had good health, 254 moderate health, 306 bad health, and 180 died by the end of the first year. Of 1000 infants raised on artificial foods, 90 exhibited good health, 147 moderate health, 253 bad health, and 510 died by the end of the first year. In other words, the mortality among children raised on infant foods was over six times greater than when nourished by mothers' milk. In the case of wet nursing the mortality was twice as great. Such enormous differences can be due only to the fact that artificial feeding, as at present practised, is in no sense a substitute for mothers' milk. The character of infant foods sold in Germany is substantially the same as of those sold in this country, and it is but fair to presume that the same difference in the death rate obtains here.

In the discussion of such a question as the value of infant foods, so many considerations arise, both of a chemical and of a physiological character, that to avoid error in drawing conclusions one must proceed with great caution. It is true that some children thrive on certain foods, and seemingly are in as good health as though sustained entirely by the mothers' milk, but it would be quite erroneous to suppose that such foods would be suitable for all children.

The only certain way we have for arriving at a conclusion with regard to the value of an infant food, is to compare it with mothers' milk. No one can deny that mothers' milk is the only perfect food for infants, and whenever a child is so unfortunate as to be deprived of that blessing, it becomes the duty of its natural protectors to provide it with a food approaching in its composition as nearly as possible that perfect type. The food of young animals is radically different from that of the older of their kind. No farmer would expect to raise young calves by turning them out to graze when only a few days old. Yet for calves there is not a greater difference between fresh grass and cows' milk than there is for infants between starchy food and mothers' milk.

For the proper support of human life, five different kinds of food material are necessary, viz: water, nitrogenous matter, carbohydrates, fat, and mineral salts. When one of these five fails, perfect health is not possible. Mothers' milk, and in fact the milk of all animals, contains these five constituents. Milk is, therefore, regarded as a perfect food. The lacteal secretion varies considerably in different animals, not only in the percentage, but also in the character of the

various ingredients. It has only been in recent years that correct methods of analysis have been discovered, so that correct ideas with regard to the composition of the various milks could be formed. Even at the present day one frequently meets with false statements from those highest in authority on the subject. For example, some of the best medical authorities assert that the great difference between woman's milk and cow's milk lies in the fact that the latter contains more solid matter, particularly more nitrogenous matter and fat. This statement is not borne out by chemical analysis, for the average percentage of solid matter in cow's milk is 12.3, while in woman's milk it is 13.3. The average fat in woman's milk is 4.01 per cent., and in cow's milk, 3.75 per cent.

Another popular idea is that asses' milk is most similar in composition, qualitatively and quantitatively, with woman's milk. Whether this be true or not, I am not prepared to say. The only evidence I can find in support of the statement is an analysis made by Doyere in 1846, in which he makes the nitrogenous matter comparable with that of woman's milk. But even in Doyere's analysis there are marked differences between the two.

Before going into the discussion of the various infant foods now in general use, it may be well to consider for a few moments the functions of the various constituents of milk in the sustaining of infant life. One or two of these food materials play a different role in infant life from what they do in that of older persons, and for that reason especial consideration should be given them.

Probably the most important part of any food, whether for infants or for persons of maturer age, is the nitrogeneous portion. The nitrogenous matter serves to build up all the tissues and fluids of the body, and under some circumstances, also serves as a source of animal heat, as well as a fat producer. However, its chief function is to supply the material from which come the tissues and fluids of the body. The importance of the proper kind of nitrogenous substance supplied to children should be a matter of careful consideration. Too often no distinction is made between the different kinds of this food constituent, though there is no other food constituent that exhibits such great diversity of both chemical and physiological properties. The relative digestibility of the nitrogenous constituents of many foods has been made the study of many careful experimenters. The results obtained by these investigators have thrown much light upon the subject of digestion, and enable the physiologist of the present day to discriminate between different foods in a

manner that was entirely impossible no longer ago than thirty years.

We are chiefly indebted to the Physiological Institute of Munich, Germany, for the many laborious and pains-taking experiments undertaken with a view of solving the question of digestion. These experiments covered a period of many years, and dealt with the digestion of most foods, under most dissimilar circumstances. With respect to nitrogenous substances, it was found that the difference in the digestibility of those of vegetable and animal origin is largely in favor of the latter.

The sugar of milk belongs to a class of food constituents that have the generic name of carbohydrates. In the food of adults the carbohydrate is not sugar, but starch. The digestive organs of man contain several distinct principles that are capable of converting starch into sugar. This last substance is the final state into which starch enters before assimilation by the system. In the case of infants, those juices capable of acting on starch are entirely wanting. There is no ptyalin in the saliva, nor is there any diastatic ferment in the pancreas, by means of which starch can be changed into glucose. The consequence of giving a child starchy food, therefore, would be not only useless, but injurious. We all know what effect substances which we can with difficulty digest have upon adults; what therefore must not a child suffer who is compelled to take into its system material that has to make its way through entirely unchanged. We rebel whenever our saleratus contains terra alba, although the percentage is very small, yet many have no hesitation in giving to infants foods whose solid matter sometimes consists of over 50 per cent. of indigestible starch. The function of carbohydrates in the human system is to maintain animal heat, and to spare the consumption of nitrogenous matter. The carbohydrate in the case of infants is a peculiar kind of sugar, called milk sugar.

One of the most important of the food constituents, and one which seems most systematically neglected in every infant food made, is the fat. The function of fat in the animal economy is to maintain animal heat, to save unnecessary use of nitrogenous matter by the system, and finally to build up the fatty portions of the body by direct addition. In the case of infants, fat not only serves these purposes, but it also evidently has another important duty to perform. In the examination of the fæces of persons after the period of complete dentition, it has been found by chemical analysis that, when the digestion is normal, very little unchanged food passes through the body, and that which is unchanged usually bears some

simple relation to the food consumed. With nursing children, however, under like circumstances, it has been found that the solid substances in the fæces consist of about 40 per cent. of fat, and 35 per cent. of mineral matter, with sometimes a little unchanged milk sugar. This being the case, fat must have a special function to perform in the intestines. The most likely supposition, and it is merely a supposition, is that the fat acts as a lubricant, and renders the passage of the food easy and smooth. It is a curious fact that many writers on the subject of infant feeding fall into the error of ascribing a small percentage of fat to woman's milk, whereas the result of hundreds of analyses show that the average percentage is considerably greater than it is in cow's milk.

The only other constituent of milk that need be noticed is the mineral matter. This is very similar in quantity, as well as in quality, to the mineral salts found in cows' milk. This mineral matter is especially characterized by the comparatively large amounts of potash salts, and of phosphates. This mineral matter of course serves an extremely useful purpose; but it is not of such vital importance in this connection as are the other constituents of this food.

It would seem most natural that when the supply of mothers' milk failed an infant, recourse would be taken to cows' milk, as being the food most like that of its natural nourishment. This was probably formerly the case; but of late years one generally resorts to one or another of infant foods, of which there are seventeen different kinds that are well known.

Of course the best possible food for a child is that provided for it by nature, and the best substitute when that fails is that food most like it in chemical and physiological properties. Before we are able to make any comparisons between the various foods, of course it is necessary to have complete and exhaustive analyses. Many analyses have been made of woman's milk, more or less complete. The first thing that strikes the reader of these analyses is the great difference in the chemical composition of this kind of milk. Some of the earlier of the analyses given are erroneous, no doubt, because there were then known no good methods of analysis. This will account for the great difference between analyses of later and earlier date; but there are differences among the analyses made in recent years. These differences are probably due to two causes: first, because of the different circumstances under which the milk may have been withdrawn from the breast, the first, middle and last portions of milk being very different in composition. The chief reason of these dif-

ferences, however, lies in the fact that the milk of woman is less susceptible to influences of food, and more dependent on what we may call temperament, than that of any other animal. During the past few years careful attention has been given to these points, and physiologists seem to agree that the average composition of woman's milk is about as follows:

Water	86.75
Fat	4.00
Milk Sugar	6.99
Nitrogenous substances	2.05
Mineral salts	.21
	100.00

Total solid substances—13.25.

In the variation of the percentages of the various constituents of woman's milk, there is the greatest difference in the nitrogenous substances, and the least in the milk sugar, while the fat occupies a place between the two.

While the percentage of the nitrogenous substances varies considerably, they never vary in their chemical composition, and are different from the nitrogenous substances generally found in animals or vegetables. They are especially characterized physiologically by their easy digestibility, and by the fact that the acid juices of the stomach do not precipitate them as clots of large size, but as small light flakes. This last phenomenon may account somewhat for their easy absorption by the system. This absorption is so complete that only the smallest traces of the nitrogenous matter of woman's milk escape assimilation. Chemically, also, these substances differ greatly with the corresponding food constituents found in the milk of other animals. It is unnecessary here to recite those differences at length. Woman's milk contains no casein, the cheese-forming constituent of cow's milk, but considerable quantities of soluble nitrogenous substances which cannot be precipitated in alkaline solution. The terms casein and albumen are so indefinite, and have such different meaning from what is usually given, that I prefer using the general term, nitrogenous substances, wherever possible. By casein is usually meant that nitrogenous substance precipitated from milk by means of dilute acid, without the aid of heat, while albumen is the portion which is thrown down by boiling after the removal of the casein. In woman's milk the first is only a small fraction of the latter. Strictly,

neither of these two terms is the proper one; still they will suffice for making clear certain distinctions.

The carbohydrate, milk sugar, found in woman's milk, does not differ, either chemically or physiologically, from milk sugar derived from any other source. It differs from cane sugar in being less sweet, and in certain chemical reactions. Milk sugar can easily be obtained, being a regular article of trade. This fact has a certain importance, because the preparation of an artificial food requires a percentage of milk sugar comparable with that of woman's milk. The maintenance of the animal heat of infants is due largely to the high percentage of milk sugar. This is evidenced by the fact that nearly all of the sugar is consumed by the infant system, while the fat, which, weight for weight, in the bodies of adults, is capable of producing much more heat than the carbohydrates, is, as we have seen, passed off to a large extent unassimilated. In foundling hospitals great difficulty is experienced in maintaining the animal heat of the infants. This probably is largely due to the small percentage of sugar usually found either in infant foods or in cows' milk.

The fats of woman's milk have never been investigated—at least no mention of the fact is to be found in recent literature. They do not differ in external physical properties from the fats usually found in other milks. The fat, as well as the sugar, of woman's milk, therefore, can be easily substituted.

Having thus taken a brief glance at what woman's milk is, and the functions of its constituents, it will be possible for us to consider intelligently the question of the artificial feeding of infants. It must be a self-evident fact that the most perfect substitute for woman's milk is that food which most resembles it, not only in chemical percentage and composition, but also that which exhibits the most similar physiological properties.

During this past year all the infant foods on the New York market were ordered for the laboratory of the University. Seventeen different infant foods were obtained. These, with one or two exceptions, were analyzed by some of the students, as well as by myself. The results of these analyses will be seen in a subsequent table. The different foods may be divided into two classes, those containing starch, or starchy foods, and those containing no starch, or Liebig foods. The starchy foods greatly exceed in number the Liebig, though probably more of the latter are sold. Farinaceous foods may be subdivided into two classes, viz: those prepared with the addition

of milk, the so-called milk-foods; and secondly, those not so prepared. The following different kinds of foods were analyzed:

FARINACEOUS FOODS.

Without Milk.—
- Ridge's Patent Food.
- Neave's Food.
- Imperial Granum.
- Robinson's Patent Barley.
- Baby Sup, No. 1.
- Baby Sup, No. 2.
- Savory & Moore's.
- Hawley's.

With Milk. Milk-Foods.
- Nestle's.
- Anglo-Swiss.
- Franco-Swiss (Gerber's.)
- Wells, Richardson & Co.'s.
- Carnrick's.

NON-FARINACEOUS.

Liebig Foods.—
- Mellin's.
- Horlick's.
- Keasby & Mattison's.
- Loeflund's.

Some of the farinaceous foods claim, in their circulars, to be Liebig foods; however, chemical analysis reveals the presence of considerable amounts of starch, and therefore their proper place is among the farinaceous foods.

Ridge's Patent Food, the first on the list, consists of a specially prepared wheat flour. The flour composing it is cooked by a steam heating process, which it is claimed largely converts the insoluble and indigestible starch into soluble and digestible dextrine. Practically, however, its conversion is only partial; the amount of soluble carbohydrates, as shown by analysis, is only 6.60 per cent., while the starch is 74.70 per cent. These figures show but little difference in composition from the original flour. The percentage of nitrogenous substances in Ridge's food is about that of good wheat flour.

Neave's Food is likewise a product of wheat flour, and is used more frequently in England than in this country. It consists of coarsely ground flour. It is distinguished by a large percentage of starch. Its properties are similar to those of like preparations.

Imperial Granum. This infant food is said to be principally the

gluten derived from a superior growth of wheat. As a matter of fact, Imperial Granum consists of baked wheat flour. Its percentage of nitrogenous substances (gluten) is not above 11—about the average of ordinary flour. Its percentage of starch is very high, while that of the soluble carbohydrates is very low. Its nutritive value is about equal to that of ordinary fine wheat flour.

Robinson's Patent Barley consists of finely ground barley flour. Although recommended as an infant food, it contains but little nutriment except starch. Its percentage of nitrogenous substances is low, as is also that of the soluble carbohydrates.

Baby Sup, No. 1, claims to be an excellent substitute for mothers' milk; really, it is nothing more than oatmeal partially malted. The effect of the malting is to somewhat lower the percentage of starch, and to correspondingly increase the amount of soluble carbohydrates. This food is specially distinguished by the large amount of cellulose it contains. Cellulose is a constituent of the whole grain of the cereals, and is not only indigestible, even by adults, but it actually prevents the assimilation of the nutritive parts of flour by the system. Its presence in an infant food is certainly not beneficial.

Baby Sup, No. 2, consists of wheat flour, malt, and mineral salts. The analysis shows the starch to be more perfectly changed to sugar, etc., than in Baby Sup, No. 1. It requires to be cooked for half an hour to effect complete conversion. It is doubtful if such cooking will transform much of the starch into soluble carbohydrates, and it certainly will have no effect upon the large amounts of cellulose that the food contains.

Savory & Moore's Infant Food is very like in composition to the last, except that the conversion of starch in it is more complete. The directions given for the preparation of this food will not bring about any further chemical change in the constituents of the food.

Hawley's Food is most like a Liebig's food of any of the preceding. It contains only a small percentage of starch, while the amount of soluble carbohydrates is proportionally great.

The last four foods are sometimes classed as Liebig's foods, but that classification must be improper, as one of the prerequisites of such a food is, that it should contain no starch. All of these four contain comparatively large amounts of starch, even when cooked.

The consideration of these pure farinaceous foods, in their relation to woman's milk, will be left until after a brief description of the so-called Milk Foods. Both classes have the same general characteristics, and consequently can be treated at the same time.

MILK FOODS.

As the name indicates, these foods contain the constituents of milk. Probably all milk foods are prepared in pretty nearly the same way. As generally understood, this preparation consists in the baking or heating of various kinds of flour, then grinding the baked mass, mixing it with condensed milk, and finally in heating the whole mixture to a certain temperature for a certain length of time. In one of these milk foods it is claimed that the cow's milk used in its preparation has been subjected to the action of extract of pancreatin. In other respects all the five foods are very similar. By the process of torrefaction to which the flour in these foods is subjected, the fat, cellulose and mineral salts contained therein suffer no material change. The starch undergoes a partial decomposition, with the formation of some dextrine. The nitrogenous constituents of the flour, however, undergo the greatest alteration. They are changed very considerably in their composition. A portion becomes coagulated, while the gluten can no longer be recognized as such. It cannot even be separated by washing from the starch. This change in the nitrogenous substances is not a kind of artificial digestion, but rather a chemical decomposition. If the heat be applied for a long time, there ensues an actual loss of nitrogen, by volatilization.

The milk foods are certainly an improvement on the ordinary farinaceous foods, but they are far from being substitutes for mothers' milk. One of the chief recommendations of these foods is, that when prepared for use, the presence of the farinaceous matter prevents the coagulation in clots of the cows' milk employed. This phenomenon is also exhibited by the ordinary farinaceous foods, but in the milk foods the previous heating of the cereals prevents the formation of an objectionable mucilaginous mass characteristic of the others.

The five milk foods analyzed exhibit the same general characteristics. Wells, Richardson & Co. have a milk food that has evidently had but a small amount of milk used in its composition; it consists chiefly of the flour of cereals.

Nestle's, Anglo-Swiss, and Franco-Swiss milk foods differ but very slightly in composition. Carnrick's food has a somewhat higher percentage of nitrogenous matter than the other four in this class, but it has less soluble carbohydrates. This food, it is claimed, consists of 50 per cent. of milk solids, and 50 per cent. of wheat flour. A very simple calculation will show that this claim is false, unless

perhaps skimmed milk were used in its preparation. Were the composition as represented, the percentage of fat would be 15.74, whereas analysis shows it to be but 6.

There is, among others, one very serious objection to the use of any of the foregoing substances as infant foods. This objection is, the presence of starch. As will be seen in an accompanying table, the amount of starch introduced by the addition of the farinaceous compound to the infant food, amounts on an average to 32 per cent. of the total solids. That is, the infant has to take into its system food adulterated by useless and injurious material to the amount of nearly one-third. Starch is not only injurious by reason of its scarcely appreciable digestion by the infant organs, but often it gives rise to a species of fermentation that is very objectionable; that is, the butyric acid fermentation. This is a frultful cause of many of the intestinal diseases of childhood.

The great chemist, Liebig, declared that infants, before dentition, are incapable of digesting starchy food. This conclusion of Liebig's has been confirmed and strengthened by the experiments and observation of later investigators. No food containing starch should, under any circumstances, be fed to young infants. It is but justice to state that some of the manufacturers of milk foods acknowledge that very young infants do not thrive on their preparations, which are designed for children of larger growth.

In the last class of infant foods—Liebig's Foods—it seems at first glance that more value ought to be attached to them than to the preceding classes. This is true, in so far as they contain nothing so strikingly injurious as starch. They are injurious only in that they give so little nutriment to the child, and hence are to be considered rather as useless, than as so very harmful.

These foods are prepared according to a formula first given by Liebig. This preparation consists, in short, in the complete conversion of the starch of flour into maltose and dextrine, by means of the diastase in barley malt. After carrying on this process of saccharization for some time, at ordinary temperatures, the whole mass is heated to a temperature considerably above that of boiling water. The residue is exhausted with water, evaporated to dryness, and sold as a Liebig's food. So far as is known there are but four true Liebig's foods now on the market. They are Mellin's, Horlick's, Keasby and Mattison's, and Loeflund's. These all closely resemble each other in chemical and physiological properties. The chief dif-

ference to be observed is that Mellin's and Horlick's contain less water, and are dry substances, while the two other are very viscid liquids. All are characterized by a sweet taste, and all dissolve nearly entirely in water. During the process of preparing these foods much of the nitrogenous matter becomes insoluble, and is lost during the manufacture, as is also nearly all the fat. Thus Liebig's foods consist essentially of water, sugar, a trace of fat, some nitrogenous substances and mineral salts. The mineral salts are largely due to the addition of carbonates of the alkalies during the process of manufacture.

The claim of the manufacturers of Liebig's foods is that, by their addition to cow's milk, the resulting mixture has very nearly the same composition as woman's milk, and that the relative digestibility of the two is about the same. This claim is not borne out by facts. The only indigestible part of cow's milk—that is, the only portion differing at all from woman's milk—is the nitrogenous portion. This, as was said before, coagulates in clots in a child's stomach, while the corresponding constituents of woman's milk coagulate in flakes. The addition of the Liebig's food to cow's milk, instead of remedying the evil, only aggravates it. In a series of experiments conducted in the laboratory of the University of Texas, it was found that when Mellin's, Horlick's, Keasby & Mattison's, and Loeflund's foods were prepared for use according to directions, the addition of a dilute acid superinduced the formation of clots from ten to twelve times as large as those produced in cow's milk diluted to the same degree, and only differing from the above preparations in the absence of the Liebig's food. When cow's milk is diluted, the coagulum formed is much smaller than is the case with undiluted milk. However, the difference in the digestibility of the two milks is not, by any means, entirely due to the character of the coagulum formed by the juices of the stomach. The real difference lies in the different character of the nitrogenous constituents of cow's milk and woman's milk. The Liebig's foods have no action whatever on the character of the nitrogenous substances found in milk. In the feeding of infants with Liebig's foods 70 per cent. of the nourishment given to the child is due to the fresh milk with which it is mixed, while only 30 per cent. is contributed by the Liebig's food, and of this 30 per cent. nearly 27 per cent. comes in the form of sugar, leaving but 3 per cent of the real nourishment due to the infant food which has been added to the cow's milk.

Even the added sugar, which serves to keep up the animal heat, occurs in quite a different form from what it does in cow's milk. As contained in the Liebig's food it is either maltose or dextrine, neither

of which substances occurs in milk. It has not been proved physiologically that they undergo the same transformations in the system that milk sugar does, and hence they cannot be regarded as fully equivalent to the latter.

In the following table will be found the results of the analyses of seventeen different infant foods:

	Water	Fat	Soluble Carbohydrates	Starch	Nitrogenous Substances	Cellulose	Ash
Ridge's Patent Food	6.30	1.00	6.60	74.70	10.60	0.28	0.52
Neave's	5.10	....	....	75.50	14.70	3.50	1.20
Imperial Granum	11.50	0.64	5.73	70.02	10.91	0.20	1.00
Robinson's Patent Barley	10.10	0.97	4.11	77.76	5.13	1.93	1.93
Baby Sup, No. 1	6.54	1.08	14.55	60.80	9.60	6.25	1.18
Baby Sup, No. 2	11.50	0.60	22.00	52.40	8.00	4.30	1.20
Savory & Moore's	8.34	0.40	44.83	36.36	9.63	0.44	0.89
Hawley's	6.60	0.61	76.54	10.97	5.38	....	1.50
Nestle's Milk Food	6.55	4.34	42.89	34.41	9.61	0.43	1.77
Anglo-Swiss Milk Food	6.50	6.00	46.00	28.00	11.20	0.38	1.92
Franco-Swiss Milk Food	4.96	4.58	44.58	32.93	13.01	0.50	1.40
W., R. & Co.'s Milk Food	7.20	1.25	32.05	46.90	10.40	0.40	1.80
Carnrick's Soluble Food	4.20	6.06	29.35	42.05	15.15	0.19	3.00
Mellin's	5.97	0.17	81.95	....	9.56	....	2.35
Horlick's	4.40	0.08	86.20	....	8.04	....	1.28
Keasby & Mattison's	28.40	....	70.50	....	0.20	....	0.90
Loeflund's	32.00	....	62.61	....	3.54	....	1.85

The analyses of these various foods represented in this way convey but little idea of their worth. We see that some contain more of one constituent than others, but no idea can be obtained of the value of these food stuffs until they are prepared ready for the nursing bottle.

It is a little strange that while all these various foods claim to make an aliment nearly or quite similar to woman's milk, yet in only one instance is there any attempt made to show this similarity. This exception is in the case of Mellin's food, and even there the example chosen is the receipt given for food for children over three months old. Even taking the figures given in this example, a close comparison will show striking differences, especially in two of the most important constituents, viz: The nitrogenous substances, and in the fat, the former being over twice as great as found in woman's milk, and the latter but a little more than half the required amount. As nearly *all* the nitrogenous matter and the whole of the fat thus given are derived from the cow's milk used, it does not appear why one cannot produce just as good, if not a better food, by adding a little sugar and water to fresh cow's milk.

To obtain a clearer conception of the exact value of these infant foods, I have made the following table, which shows the percentage composition of each infant food, when prepared according to the printed directions on each bottle or can. To make my meaning more clear, the following table shows the composition of each infant food as consumed by the child.

The figures were obtained by simple mathematical calculation. On each package are printed directions for preparing the food; that is, one is to take so much of the food, so much of water, and so much of milk. Now if we know the average composition of cow's milk, and the composition of the infant food, it is only a question of multiplication and division to find out exactly what the child takes into its stomach.

	Woman's Milk	Ridge's Food	Neave's Food	Imperial Granum	Robinson's Patent Barley	Baby Sup, No. 1	Baby Sup, No. 2	Savory & Moore's	Hawley's	Nestle's Milk Food	Anglo Swiss Milk Food	Franco Swiss Milk Food	Wells, Richardson & Co.'s Milk Food	Carnrick's Soluble Food	Mellin's	Horlick's	Keasby & Mattison's	Loeflund's
Water	86.75	94.20	92.27	92.62	94.61	95.99	92.12	91.50	93.74	91.50	93.46	90.50	92.35	91.28	91.21	90.24	90.88	91.08
Total solids	13.25	5.80	7.73	7.38	5.39	4.01	7.88	8.50	6.26	8.50	6.54	9.50	7.65	8.72	8.79	9.76	9.12	8.92
Fat	4.00	0.90	1.21	1.85	0.06	0.75	1.85	1.58	0.41	0.39	0.42	0.46	1.25	0.56	1.81	1.80	1.79	1.79
Soluble carbohydrates	6.99	1.24	1.45	2.27	0.25	1.12	2.71	3.92	4.51	3.90	3.31	4.46	2.73	2.67	4.64	5.66	5.38	4.96
Nitrogenous substances	2.05	1.10	1.65	1.84	0.31	0.84	1.86	1.20	0.64	0.87	0.79	1.30	1.52	1.38	1.95	1.93	1.62	1.78
Mineral salts	0.21	0.16	0.25	0.32	0.11	0.25	0.35	0.15	0.13	0.16	0.13	0.14	0.27	0.27	0.34	0.37	0.34	0.39
Starch	....	2.40	3.17	1.10	4.66	1.05	1.11	2.65	0.57	3.13	1.89	3.29	1.88	3.84	....	....	....	....
Total solids less starch	13.25	3.40	4.57	6.28	0.73	2.96	6.77	5.85	5.69	5.37	4.65	6.21	5.78	4.88	8.79	9.76	9.12	8.92
Fat and nitrogenous substances from Inf. Food	....	0.29	0.59	0.16	0.37	0.19	0.18	0.73	0.30	....	...	....	0.47	....	0.29	0.27	....	0.15
Fat and nitrogenous substances from milk	....	1.71	2.26	3.53	....	1.40	3.52	1.05	0.75		....	....	2.29	....	3.47	3.44	3.41	3.42

The first most striking result brought out by these calculations is the enormous difference between the total amount of solid matter contained in mothers' milk and in the prepared infant foods. Hardly any of these foods contain much more than half as much as is present in woman's milk. If we leave out of consideration the starch in the first thirteen of these foods, as ought to be done, because starch is in no sense a food material for infants, not one of the foods contains half as much solid matter as is to be found in woman's milk. In other words, in order for an infant to obtain as much nourishment as is contained in one pint of woman's milk, it will be compelled to drink from two to five pints of these foods, and in the case of Robinson's Patent Barley, would have to drink nearly twenty pints, or two gallons and a half.

The same discrepancy would be shown in the Liebig's foods, did they not derive a large portion of their nutritive properties from the milk used in diluting them, and were they not themselves principally sugar.

When we consider such great dissimilarities between the natural and artificial foods of infants, it is a wonder that so many children fed upon the latter survive. Viewed in the light thrown upon them by chemical analysis, and considered from a physiological standpoint, it is surprising that foods of such a character can find recommendations from any one. When we read among the directions printed on some of the labels, that for constipation increase the amount of the infant food, while for diarrhœa increase the amount of water, we cannot help translating such recommendations in this way: For constipation, irritate the stomach a little more; while for diarrhœa, starve the child a little more.

This great difference between the natural and artificial food is also strikingly shown in the consideration of the individual constituents. In woman's milk, for instance, the average amount of fat is 4 per cent. Notwithstanding the great variation in the percentage of fat in woman's milk, it is never less than 2.10, while nearly always it is much greater than this amount. In none of the foods prepared for use is the percentage of fat as high as 2.00; on the contrary, it runs from 0.06 to 1.85. The importance of large amounts of this food constituent has already been mentioned. In the case of the carbohydrates even, in no instance does the percentage run up as high as in woman's milk. The child, therefore, can scarcely keep up the necessary heat in its system by the use of such foods.

In the nitrogenous substances, also, is the percentage much lower than is called for by the normal food.

It is hardly necessary to dwell upon the differences as exhibited by the last table. They speak for themselves. Were the constituents of these foods exactly the same in composition as those of woman's milk, yet if an infant be fed on them according to directions, it would still have insufficient nourishment.

It might be asked why not increase the total amount of solid matter by increasing the amount of infant food used. This cannot be done in the case of the farinaceous foods without increasing the percentage of starch so much that it would actually form a pap, and not a liquid. In the case of the Liebig's foods, this cannot be done without using cow's milk entirely, which would render the percentage of nitrogenous substances too great, and besides would be only equivalent to an addition of sugar to cow's milk.

To make a resume, it would appear, both from physiological as well as from chemical grounds, that none of the infant foods now on the market can be regarded as a proper substitute for woman's milk. The reasons for arriving at this conclusion are as follows:

1. No infant food, as now sold, can be made up, either with or without the addition of cow's milk, so as to produce a liquid having as great an amount of total solids (13.75 per cent.) as are in woman's milk, unless indeed such total solids consist of such an injurious substance as starch, or the casein of cow's milk.

2. Not one of these infant foods is composed of nitrogenous matter that is as easy of digestion as is that of woman's milk. The chief source of such nitrogenous matter is cow's milk, and not the foods themselves. The fact that starchy matter prevents the formation of clots in cow's milk is no reason for introducing a still more indigestible substance in a child's stomach than would be the clots themselves. Besides, the formation of a clot is not the only reason of the greater indigestibility of casein.

3. The percentage of fat is uniformly too low for the requirements of the infant organism.

4. Because the soluble carbohydrates, even when present in large amounts, are different in chemical properties, and most likely also in physiological, from the milk sugar contained in woman's milk.

5. Chiefly because the great majority of infant foods introduce a substance into the stomach of the child which is never found in woman's milk, and which we know by direct proof cannot be assimilated by the digestive system of an infant.

6. In those cases where there is an approximation to woman's milk, this approximation is due to the use of cow's milk. The use of such foods as Liebig's are not so objectionable as the farinaceous; they are only useless, because their only function practically is to increase the percentage of the carbohydrates. This increase can be as well and more cheaply made by the addition of a little ordinary sugar, or still better by milk sugar. The addition of Liebig's food does not change the character of the nitrogenous matter of cow's milk, either before or after it is taken into the stomach.

The question now arises, What can be used as a substitute for woman's milk? The answer to this question was made six years ago, at a meeting in Salzburg of some of the leading physiologists and physicians of Germany. They decided that, while cow's milk, as such, could never become a perfect substitute for woman's milk, still it was the food that most closely resembled it in chemical and physiological properties. The greatest dissimilarity between the two is the difference in the properties of the nitrogenous substances, and in the difference of the amounts of the other different milk constituents. The first difference has been sufficiently dilated upon. The last difference will be most clearly indicated by the following table, which gives the average composition of woman's milk and of cow's milk:

	Woman's Milk.	Cow's Milk.
Water	86.75	87.70
Fat	4.00	3.74
Sugar	6.99	4.50
Nitrogenous substances	2.05	3.42
Mineral salts	0.21	0.64
	100.00	100.00

Were the physiological properties of the nitrogenous constituents of the two milks identical, the composition of an artificial human milk from cow's milk would not be difficult. By a proper admixture of milk, water, cream and milk sugar, such a milk could be compounded so as to approximate very closely to woman's milk. When cow's milk is somewhat diluted with water, the formation of clots is avoided to a considerable extent, and the rapidity of the digestion of the nitrogenous matter proportionately increased. In the infant foods previously considered, the most unsuitable were those that used the least cow's milk in their preparation, while those that were nearest to woman's milk in composition used the most.

If we take the average compostion of cream to be:

Water	65.51 per cent.
Fat	26.75 "
Milk sugar	3.52 "
Nitrogenous substances	3.61 "
Ash	0.61 "
	100.00

We can readily form a milk whose composition, as far as percentages are concerned, and also as far as physiological characteristics, except in the case of the nitrogenous matter, very closely resembles human milk. Such a milk, compounded in the laboratory, gave the following composition. It is placed side by side the analysis of an average sample of woman's milk, and was made according to this formula:

Cow's milk	1 pint.
Water	¾ pint.
Cream	5 tablespoonfuls.
Milk sugar	3 tablespoonfuls.

Analysis gave:

	Woman's Milk.	Artificial Milk.
Water	86.75 per cent.	86.67 per cent.
Fat	4.00 "	4.00 "
Milk sugar	6.99 "	7.00 "
Nitrogenous substances	2.05 "	2.00 "
Ash	0.21 "	0.33 "
	100.00	100.00

A milk prepared according to this formula is certainly much superior to any infant food, because it so much more nearly resembles woman's milk in its composition, the only difference being in the case of the nitrogenous substances, which, though present in the proper amounts, are still chemically and physiologically different from those of woman's milk. Another difference, though of less importance, is that woman's milk is uniformly alkaline, while cow's milk is uniformly acid a few minutes after withdrawal from the udder. This difference can easily be remedied by the addition of a suitable alkaline salt.

The true solution of the problem lies in the changing of the nitro-

genous substances of cow's milk in such a way that they will be readily digested, and at the same time will lose none of their value as a food. It can be said that this problem has been solved. Dr. Pfeiffer, of Wiesbaden, proposed to use an extract of pancreatin to cause a partial digestion of the casein of cow's milk before its introduction into the stomach of an infant. One of the constituents of the pancreatic juice, trypsine, has the power of partially digesting the casein of cow's milk, with formation of peptone, a nitrogenous substance easily digested, non-coagulable by acids or heat, and possessing nutritive qualities fully equal to those of like substances. Having this ferment at our hand, we need no longer resort to the use of a so-called infant food, nor to the less injurious artificially prepared cow's milk just mentioned.

If the proportions of milk, water, cream, and milk sugar given just above be treated with a little extract of pancreatin for a few minutes, we can obtain a milk almost identical in every respect with average human milk. Some manufacturers have availed themselves of this scientific discovery, and now offer for sale a compound consisting of milk sugar, extract of pancreatin, and an alkaline carbonate. This mixture, when added to milk and cream in the proper proportions, gives a milk that is probably as perfect a substitute for woman's milk as is possible to be made. Nothing, however, can fully replace the mother's milk itself.

This discovery of the peptonizing of cow's milk, for the purpose of preparing an artificial human milk, is certainly one of the most important contributions made to physiological chemistry for many a year, and it will doubtless be the means of saving the lives of many children.

The great mortality among children fed by the infant foods sufficiently corroborates the evidence against them, furnished on theoretical chemical and physiological grounds. Whether the peptonized milk will stand the test of time, cannot be foretold. One can only say that, if we interpret science aright, it promises to be a very boon to infants.